THE TRICHONOCARDIASES

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PLATES XXXVI—XXXVII

INTRODUCTORY

The literature relating to the Trichonocardiases being of such recent date and of such small bulk, together with the fact that this is the first record of their occurrence in the Anglo-Egyptian Sudan, and, as far as we know, in Africa, has induced us to bring forward the following observations.

HISTORICAL

A number of affections of hairs have been described which are characterized by the presence of variously coloured nodes, nodosities and more or less elongated unilateral, bilateral or annular thickenings on hairs in various parts of the body. The nodes are confined to the shaft, and do not penetrate into the hair follicle. These affections may be classified as the Trichosporoses, Lepothrix and the Trichonocardiases.

Trichosporosis was first described as a rare disease of the hair of the head in native women living in the valleys of the province of Cauca on the slopes of the Eastern Cordilleras of Colombia. It has been observed in Rio de Janeiro and Germany. It also occurs on the hair of the beard in men. Osorio gave it the name 'Piedra,' because of the stony hardness of the nodules, but the more correct name is Trichosporosis tropica, as its causal organism is *Trichosporum giganteum*, Behrend, 1890. A similar condition has been

briefly described by Castellani as occurring in India and Ceylon, but so far, he has not named the fungus, which appears to differ from *T. giganteum.*

The remaining Trichosporoses belong to temperate climates; they are:—

Biegel's Trichosporosis, or Tinea nodosa of Cheadle and Morris, due to *Trichosporum beigeli* (Rabenhorst, 1867). It was first found by Lindemann in 1865, and is often called the Chignon fungus. It occurs on the hair of the head.

Unna's Trichosporosis, or Piedra nostras, found on the hairs of the beard and moustache, and due to *T. ovale* (Unna, 1896).

Behrend's Trichosporosis, or Nodular trichomycosis, found on the hairs of the beard, and due to *T. ovoïdes* (Behrend, 1890).

Du Bois' Trichosporosis, found on the hairs of the pubic region, and due to *T. glycophile* (Du Bois, 1910).

Another nodular hair disease is Lepothrix, or scaly hair, which was discovered by Paxton in 1869, was named by Wilson, and described by Eisner and Crocker. It is characterized by variously coloured grey, yellow, or brown nodules, which surround the hairs of persons who perspire profusely. The hairs most usually attacked are those of the axillae, but the disease may also be found on those of the chest, pubes, and inside of the thighs. It is common in Germany, and is believed to be due to a diplococcus forming zoogloea masses. Allied to Lepothrix is the affection called Trichomycosis capillitii by Winternitz in 1903, which is said to be due to a straight or slightly bent bacillus. The descriptions of these conditions suggest that there may be some confusion, and that in reality they may be Trichonocardiases in which either only the diplococcus has been observed or in which only the bacilliform fungus has been seen. In any case it would seem that the disease Lepothrix requires further investigation, especially as Crocker's excellent description closely agrees with Trichonocardiasis.

The Trichonocardiases are allied in appearance to Lepothrix, but differ therefrom in the fact that they are all due to a fungus *Nocardia tenuis* (Castellani, 1911), either alone as in Trichonocardiasis flava (Pl. XXXVI, figs. 1 and 2; Pl. XXXVII, fig. 13), or in association with a Micrococcus as in Trichonocardiasis nigra (Pl. XXXVI, figs. 4 and 5; Pl. XXXVII, figs. 14, 15 and 20), and

T. rubra (Pl. XXXVI, figs. 6 and 7; Pl. XXXVII, figs. 16, 19 and 22). They were first described by Castellani in 1911 in a paper published in the British Journal of Dermatology, and this description was extended by the same author in 1912 in an article published in the Transactions of the Royal Society of Medicine, and still later, in 1913, in the second edition of the Manual of Tropical Medicine published by himself and one of us. He named the disease Trichomycosis axillaris, and sub-divided it into three varieties, flava, rubra and nigra; but as it occurs on the hairs of the pubes, in some cases without any axillary infection, we are of the opinion that Trichonocardiasis is a better term.

Attention has, very briefly, been drawn to Castellani's work by Jackson and McMurty in their book on 'Diseases of the Hair,' published in 1913, where they devote a small section to the subject under the title 'A Disease resembling Lepothrix.'

So far as we know, the above comprise the total literature on the subject of the Trichonocardiases.

GEOGRAPHICAL DISTRIBUTION

We have found the three varieties of Trichonocardiasis in the Anglo-Egyptian Sudan, and one of us has observed a condition resembling Trichonocardiasis flava in Europeans on the Gold Coast, West Africa, as long ago as 1898.

As the three varieties may be found on one and the same person, and, indeed, in the same axilla, we do not propose to give separate descriptions of each variety, but to describe the disease Trichonocardiasis as a whole, mentioning the difference between the three varieties when necessary.

At present the Trichonocardiases are only known to exist in the Tropics, i.e., in Ceylon, the Anglo-Egyptian Sudan, and on the Gold Coast. These regions being so widely separate one from the other, it is reasonable to suppose that the disease will be found in other tropical regions when looked for.

Castellani has drawn special attention to the fact that he found his cases in the hot, damp districts of Ceylon, and adds that it will probably be found occurring in every low-lying tropical region. While our Gold Coast cases support Castellani's views, the cases we

have found in Khartoum demonstrate that the disease may also occur in a hot and dry climate and at a certain elevation. We found our first cases here in the month of May of this year, when the highest shade temperature was 112·2° F. (44·5° C.), and the mean shade temperature was 105·9° F. (41° C.). During this time the least percentage humidity of the air was 4% and the average 21%, while the evaporation from Piche's tube rose as high as 30·1 millimetres. As the elevation of Khartoum is 390 metres above sea-level at Alexandria, it is not low-lying. We, however, agree with Castellani that the disease will probably be found in many tropical regions, low-lying or elevated, if looked for.

RACIAL DISTRIBUTION

Most of our cases have occurred in Europeans, but Castellani has seen it among the Sinhalese and we have met with it in a negro. Possibly its occurrence was noticed long ago by native doctors, and may be one reason why so many native races shave the axillae.

BODY DISTRIBUTION

So far we have only seen the infection on the hairs of the axillae, pubic regions, and folds of the groin and in this we are entirely in agreement with Castellani.

The reason for the distribution appears to us to be the nutrition of the causal fungus *Nocardia tenuis*, as it would appear to require a mixture of human proteid material such as is found in blood serum and normal saline before it will sprout. As we shall point out later, it derives its nutriment from the lymph of the cortex of the hair while at the same time it is bathed by the saline sweat of the axillae, pubic regions, and groins, and this appears to be the reason of its affinity for these particular parts of the body.

AETIOLOGY

The causal agent is *Nocardia tenuis* (Castellani, 1911) (Pl. XXXVI, fig. 9; Pl. XXXVII, fig. 17), either alone as in the variety Trichonocardiasis flava, or associated with *Micrococcus nigrescens* (Castellani, 1911) as in Trichonocardiasis nigra, or with *Micrococcus castellanii* (Chalmers and O'Farrell, 1913) (Pl. XXXVII, fig. 18) as in Trichonocardiasis rubra.

We will now consider these aetiological factors seriatim.

NOCARDIA TENUIS (Castellani, 1911). This organism can be readily seen in cleared specimens of the infected hairs mounted in gelatin or Canada balsam as minute rod-like or bacillary forms often lying more or less parallel to one another and embedded in an amorphous ground substance (Pl. XXXVII, fig. 22), probably excreted by the fungus. This ground substance, as will be explained later, is fixed to the cortex of the hair, and lies under the cuticle and some of the superficial layers of the cortex.

When individual hyphae are examined after coloration by any of the ordinary stains, they are seen to be narrow, elongated, unbranched, non-septate rods resembling bacilli (Pl. XXXVI, fig. 9; Pl. XXXVII, fig. 17). They may be short or long, straight or slightly curved, but they are always fairly and usually very narrow.

A series of measurements gives the average length as varying from about 2·0 to over 7·0μ, and the average breadth from 0·14 to 0·3μ.

Each hypha is enclosed in a cell wall, inside which lies the cytoplasm, which may stain very lightly with the colouring agent used, but may also stain fairly darkly, especially in certain areas. No nucleus can be demonstrated and the cytoplasm appears to be homogeneous except at certain places where well-defined deeply staining rounded granules may be seen (Pl. XXXVI, fig. 9). These granules, which measure about 0·14 to 0·3μ in transverse diameter, may be situated at one end of the hypha, as in Pl. XXXVI, figs. 9, 10, 12, and Pl. XXXVII, fig. 21, or this may be placed at regular intervals through the cytoplasm (Pl. XXXVI, fig. 9), or one may be at one end while others may be close together near the opposite pole. We have not met with any branched forms, except in cultivation, but we have seen forms with one end rather bulbous, resembling in miniature the club forms of some other Nocardias. We have not succeeded in cultivating this fungus permanently, in bulk, or pure cultivation, but we have succeeded in inducing growth by placing scrapings from the hairs in equal parts of human blood serum and 0·85% normal saline solution in hanging drop preparations. These were first kept for twenty-four hours at the room temperature, which varied from 90° F. (32·2° C.) at night to about 105° F. (40·6° C.) in the day, and were then placed in an incubator at 104° F. (40° C.).

Under these conditions the fungus quickly grew out of its amorphous bed (Pl. XXXVI, fig. 10) into the surrounding liquid, and proceeded to develop in the manner depicted in Pl. XXXVI, fig. 12, and Pl. XXXVII, fig. 21, the latter of which is a microphotograph.

It will be noticed that the branching is monopodial, and that the hyphae are non-septate.

With regard to its position in the vegetable kingdom it is obvious that, as it possesses neither chlorophyll nor chromatophores, it must belong to the class Fungi, and that it belongs to the fungal order Deuteromycetes or Fungi imperfecti, because its life-cycle is unknown. Further, it can be placed in the sub-order Hyphomycetes because perithecia, asci and immersed stroma are also unknown. Of the families of the Hyphomycetes it belongs to that of the Mucedineae because its hyphae are pallid and do not cohere to form a compound stem-like structure. Lastly, it may be grouped with other forms in the genus *Nocardia* (Toni and Trevisan, 1899), which is defined as consisting of mycelial filaments of various sizes, but generally very thin (one micron or less in diameter), often branching, non-septate, and without differentiated nuclei.

Nocardia tenuis (Castellani, 1911) may therefore be defined as follows:—

Nocardia composed of thin, bacillary-like hyphae, varying from about 2 to over 7μ in length, and from 0·14 to 0·3μ in breadth, embedded in an amorphous ground substance attached to the cortex of the axillary and pubic hairs of man in tropical countries.

MICROCOCCUS NIGRESCENS (Castellani, 1911). This coccus has been grown in pure culture by Castellani, who has described its biological characters on page 1521, and has illustrated its cultural appearances in fig. 8 on Plate V of the second edition of the Manual of Tropical Medicine mentioned above. It is therefore unnecessary for us to go into details with regard to this organism, except to say that Trichonocardiasis nigra appears to be much rarer here than the flava or rubra, while the pigmentation on the hairs and in the growths we have obtained is relatively scanty, and we have found it difficult to isolate and grow *Micrococcus castellanii* (Chalmers and O'Farrell, 1913). Castellani in Ceylon found that it was more difficult to isolate and grow this coccus than was the case with *Micrococcus nigrescens*. On the other hand, we,

in Khartoum, have found quite the reverse: we have found it exceedingly difficult to obtain the black coccus with anything beyond a trace of black pigment, while the red coccus grows easily and well.

It is very readily separated out by sowing scrapings from the hair, or pieces of the hair on sloped agar, and picking out either the red colonies which require some time to develop the reddish pigment, or the yellow colonies which always appear first and in which the red pigment subsequently shows itself.

MICROCOCCUS CASTELLANII is a round or oval coccus, measuring from about 0·3 to about 0·7 μ in diameter (Pl. XXXVII, fig. 18). It is divided medianly by a clear central line into two half-moon shaped segments, thus producing the well-known diplococcal appearance. The cocci, which may occur singly or in groups, are colourless and non-motile, but excrete an amorphous non-granular lemon chrome-coloured pigment (classified according to Ridgway's Colour Standards), which lies between the individual cocci.

In old cultures another pigment of dark brownish-red colour appears (according to Ridgway's Standards this colour is madder-brown), but its relationship to the earlier yellow pigment can easily be proved by removing some of it and suspending in a sufficiency of distilled water, when the fluid at once resembles a similar suspension of the yellow pigment. If, however, this is done in a very small quantity of water, a faint reddish tinge can be observed. The best medium for showing the striking yellow pigment is the potato, when in twenty-four hours the growth assumes the appearances depicted on Pl. XXXVI, fig. 11. In order to demonstrate the red pigment it is necessary to cultivate the microccocus for some time. The medium on which this pigment shows best is the ordinary agar slope, which, when old, exhibits the dark-red pigment in the centre and the yellow pigment at the sides (Pl. XXXVI, fig. 8). The yellow pigment is seen both in aërobic and anaërobic growths. In broth and peptone water or liquid blood serum, whether grown aërobically or anaërobically, the pigment is not visible until a very abundant growth appears, when the yellow colour can be seen.

The coccus colours with all the ordinary staining re-agents, and as a rule is decidedly Gram positive. It must, however, be admitted that even in preparations showing most of the cocci well coloured

when treated by Gram's methods, a few may be seen quite decolourised, and we have also seen cocci with one demi-lunar segment well stained while the other was completely decolourised. We have failed to demonstrate a capsule around the coccus.

The organism grows aërobically and also anaërobically. The optimum temperature appears to be 37° C., but it can also be cultivated at the room temperature, which in Khartoum at this season of the year is seldom less than 32·2° C. It also grows at 20° C. on agar slopes, but not as abundantly as at 37° C., and is therefore less pigmented. Its rate of growth depends somewhat upon the medium, as it grows quickest and best on potato, and next best on ordinary or glycerin agar. On solid media it gives rise to a yellow growth at first; but on most agar media, if kept long enough, some red coloration will subsequently be found. The best medium for the red coloration appears to be the ordinary agar slope. With regard to the other agar media, it grows well on glucose and maltose agar. Like *Micrococcus nigrescens*, it produces neither acid nor gas in the following media:—

Peptone-sugars: Glucose, Laevulose, Galactose, Arabinose, Maltose, Lactose, Saccharose, and Raffinose.

Peptone-carbohydrates: Dextrin and Inulin.

Peptone-glucoside: Amygdalin.

Peptone-alcohols: Erythrite, Adonite, Dulcite, Isodulcite, Mannite, Sorbite, and Inosite.

It grows slowly on blood serum, which it does not liquefy, and well in broth and peptone water, in which it forms a general turbidity. It does not produce indol.

In agar stabs the growth is confined to the line of puncture and to the formation of a small yellow knob on the surface, in other words, the growth is filiform.

With regard to its systematic position in the family *Coccaceae* (Zopf, emended Migula), it must certainly be grouped with the genus *Micrococcus* (Hallier, 1866, emended Cohn, 1872).

In this genus it certainly belongs to those forms which grow well on agar media and are Gram positive, and in this division it belongs to the sub-division which produces colours.

The cocci of this sub-division which possess red coloration are

only three in number, *Micrococcus roseus* (Bumm, 1885), *Micrococcus ruber* (Trommsdorff, 1904), and *Micrococcus rubidus* (Hefferan).

Under the term *M. roseus* (Bumm, emended Lehmann and Neumann) are gathered a large number of rose coloured diplococci which are not known to be parasitic, and which produce growths on potato which are limited to the streaks. These growths are faint rose red in colour within an oily lustre, and are often surrounded by a whitish glistening zone, thus giving rise to a very different appearance from that produced by *M. castellanii. Micrococcus ruber* (Tromsdorff, 1904) or, as it is sometimes named, *M. chromidrogenus ruber*, which was isolated from axillary hairs, is characterised by the fact that it does not grow on potato, its colouring matter is not soluble in water, and when treated by sulphuric acid the red colour turns blue-green, while *M. castellanii* does grow on potato and its colouring matter is unaffected by 25 per cent. sulphuric acid. Moreover, *M. ruber* is associated with chromidrosis, while *M. castellanii* is not. With regard to *Micrococcus rubidus*, it is impossible to obtain any information as to its characters in Khartoum, but it appears to be closely related to *M. roseus* var *carneus*, and to be non-parasitic.

We, therefore, are of the opinion that the organism which we are describing is not the same as any species of Micrococcus so far named, and therefore give it the appellation *Micrococcus castellanii*, Chalmers and O'Farrell, 1913.

METHOD OF INFECTION

There is no doubt in our minds that the usual method of infection is from man to man, and we base this opinion upon the following observation:—

A young European, known to be quite uninfected with these parasites, became greatly interested in our work; he examined the cases which came to the laboratory, and handled and examined the fresh hairs removed from the axillae.

When he visited the laboratory he was clad in tennis attire, and as he moved about, his shirt rucked up from below repeatedly, and whenever this happened he adjusted it by pulling forward his leather belt with one hand while he pushed the soft shirt downwards inside his trousers with the other. Two weeks after examining the

cases he first noticed a reddish appearance on the hairs of the pubes. On examination it was found that the hairs were infected with the red variety of Trichonocardiasis, that is to say, with the variety which he saw and handled in abundance. It grew rapidly on the pubic hairs, but did not extend to the axillae. Moreover, it only grew in the fold of the left groin, where sweat is apt to accumulate. It did not spread to the right groin.

INCUBATION PERIOD

It would therefore appear as though two weeks were required to elapse before an infection produces sufficient growth on the hairs to attract attention, even when it is being looked for.

PATHOLOGY

The pathology of the infection appears to be quite simple. The fungus arriving upon the hair grows and pushes its way at first under a cuticular scale and then quickly works its passage into the cortex, raising, in so doing, its superficial fibres, which, together with the cuticular scale, form a covering or protection for the fungus (Pl. XXXVII, fig. 19), which probably finds the nutriment it requires in the fluids of the cortex of the hair. Once established in position the fungus does not penetrate deeper into the cortex, but, on the contrary, grows outwards, forming the nodosities, rings and sheaths to the hair which have already been mentioned. It is owing to this method of growth that the hair is so little affected, as the deeper layers of the cortex, the medulla and the root of the hair are not involved in our cases.

MICROSCOPICAL ANATOMY

In an early stage of the infection the cuticle and some fibres of the cortex (Pl. XXXVII, fig. 13, shows this stage at three places between the large clumps of fungus) may be seen to be raised in ridges, which run in wavy lines across the shaft of the hair transversely to its long axis. Under these ridges masses of the fungus may be seen growing.

A parasitic mass is composed of a firm homogeneous ground substance, in which the rod-like hyphae of the *Nocardia* may be seen

(Pl. XXXVII, fig. 22). In this the cocci are also found which are responsible for the coloration of the black and red Trichonocardiases.

SYMPTOMATOLOGY

As already stated the shortest incubation period with which we are acquainted is two weeks. The infection causes no general symptoms and is only discovered by accident by the patient, who then seeks advice in order to know what is taking place. Very often the infection is first met with while the patient is being examined by his medical attendant for some other disease. In regiments it is usually found during a general medical inspection.

The regions of the body which are affected are the axillae and the pubes, most commonly the former alone or in conjunction with the latter, and less commonly only the latter. The hairs of these regions may be affected with one or more of the three varieties already mentioned.

On examining with the naked eye an axilla affected by the yellow variety, it will be noticed that the hairs are covered with a thick or thin yellow deposit (Pl. XXXVI, fig. 1), as though the natural grease had accumulated, and, indeed, this is the reason why some persons ask about the complaint, as they consider that it reflects upon their habits. If the black variety is present it will appear as black or very dark patches, short or long, thick or thin, on one side of or ensheathing the hair (Pl. XXXVI, fig. 5), and the same description holds good for the red variety (Pl. XXXVI, fig. 7), with the exception of the difference in colour. These observations are easily confirmed by microscopical examination, when the masses may be seen encircling the hair, lying on both sides or merely forming excrescences on one side of the shaft. The cuticle and fibres of the cortex may be seen covering the small masses or embedded in the large ones.

As already stated, the disease is confined to the shaft of the hair, the health of which it does not affect. The infection of the hair does not appear in any way associated with excessive sweating, though, of course, the amount of this excretion produced by the axillae is considerably greater in the tropics than in the temperate zone, and, therefore, in warm climates the axillae are generally

damp and the pubic regions are also damper than usual. Probably it is the dampness of these areas of the body which determines the distribution of the infection, as it has so far never been seen on the hairs of the head, face, arms and legs.

The infection dies away on return to a temperate climate, especially in winter.

DIAGNOSIS

The appearance of minute nodules, rings or sheaths of a yellow, black or red colour on the hairs of the axillae or pubes indicates the presence of either Lepothrix or Trichonocardiasis.

The latter may be differentiated from the former by demonstrating the presence of *Nocardia tenuis*, Castellani, 1911, which is absent in Lepothrix.

From Trichosporosis tropica or Piedra it may be distinguished by the fact that it does not attack the hair of the head or face, and also by the difference in the causal parasite. From the other Trichosporoses it may be separated by its distribution and by the presence of *Nocardia tenuis*, as well as by the absence of a Trichosporum.

PROGNOSIS

It appears to have a marked tendency to remain in the region or regions which it first invaded, and does not, as far as our observations go, tend to spread over the body.

TREATMENT

We have found the treatment recommended by Castellani to be quite useful, viz., a lotion of one drachm of formalin to one ounce of water applied twice daily to the affected hairs, while a 2% sulphur ointment is used at night.

PROPHYLAXIS

The infection appears to be only mildly contagious; still it does tend to spread in communities. Cases which are likely to be sources of infection should have their clothes disinfected before being washed. During the infection the underclothing should be dusted with some antiseptic powder, e.g., dermatol, one drachm in one ounce of venetian talc, or with a boracic acid dusting powder.

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KHARTOUM,
September 15th, 1913.

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EXPLANATION OF PLATES.

PLATE XXXVI

Fig. 1. Trichonocardiasis flava. Natural size.

Fig. 2. Trichonocardiasis flava. × 60.

Fig. 3. Trichonocardiasis flava. × 40.

Fig. 4. Trichonocardiasis nigra. × 60.

Fig. 5. Trichonocardiasis nigra. Natural size.

Fig. 6. Trichonocardiasis rubra. × 20.

Fig. 7. Trichonocardiasis rubra. Natural size.

Fig. 8. *Micrococcus castellanii;* old culture on an agar slope. Natural size.

Fig. 9. *Nocardia tenuis*; separate hyphae. × 1,200.

Fig. 10. *Nocardia tenuis* sprouting out from the ground-substance; hanging drop preparation. × 1,500.

Fig. 11. *Micrococcus castellanii*; 24 hours' growth on potato. Natural size.

Fig. 12. *Nocardia tenuis*; growing in hanging drop preparation. × 1,500.

PLATE XXXVII

Microphotographs of the Trichonocardiases.

Fig. 13. Trichonocardiasis flava. × 60.

Fig. 14. Trichonocardiasis nigra. × 60.

Fig. 15. Trichonocardiasis nigra. × 60.

Fig. 16. Trichonocardiasis rubra. × 60.

Fig. 17. *Nocardia tenuis*, Castellani, 1911. × 1,200.

Fig. 18. *Micrococcus castellanii*, Chalmers and O'Farrell, 1913. × 1,500.

Fig. 19. Hair showing the fungal growth elevating the cuticle and the superficial fibres of the cortex. × 500.

Fig. 20. Trichonocardiasis nigra. × 60.

Fig. 21. *Nocardia tenuis* growing in a hanging drop preparation. × 1,200.

Fig. 22. Fresh preparation of a hair affected with Trichonocardiasis rubra, showing the radiating hyphae at the periphery and the optical section of the hyphae in the centre. × 700.